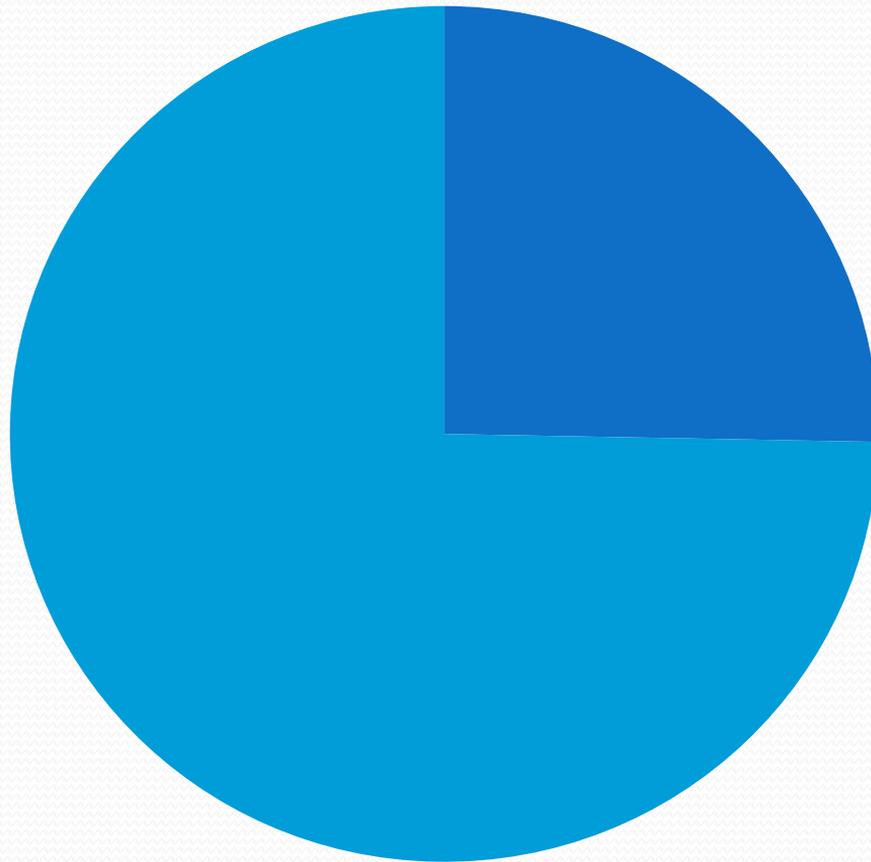


Poster Award Ceremony



Voter Turnout



- Voters
- Non-Voters

Third Place

Total Points: 27

Audience Points: 4

Judge Points: 23

Owner: Nils Bartels

Title:

Design and qualification of a recessed satellite cornercube retroreflector for ground-based attitude determination via satellite laser ranging

Institute of Technical Physics

Design and qualification of a recessed satellite cornercube retroreflector for ground-based attitude determination via satellite laser ranging

Nils Bartels¹, Paul Allenspacher¹, Sven Bauer², Daniel Hampf¹, Benjamin Rödiger³, Wolfgang Riede¹

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Introduction

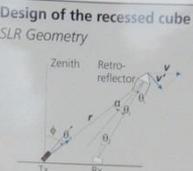
The German Aerospace Center (DLR) is working on the development of compact laser communication payloads for low-earth orbit (LEO) satellites.



- DLR-BT Paving Laser**
 - Open-Loop Body Pointing
 - Data rate: up to 200 Mbit/s
- DLR-BT SBR**
 - Classed-Laser Body Pointing with Tracking Sensing
 - Data rate: up to 1 Gbit/s
- DLR-BT CubeSat**
 - Active Beam Steering combined with body pointing
 - Data rate: up to 500 Mbit/s
- DLR-BT**
 - Active Beam Steering with Coarse Pointing Assembly
 - Data rate: up to 10 Gbit/s and more

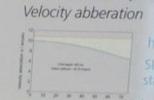
Design of the recessed cube corner retroreflector (CCR)

SLR Geometry



Emitter (Tx) and receiver (Rx) are typically collocated, apparent receiver angle θ , due to velocity aberration α

Velocity aberration

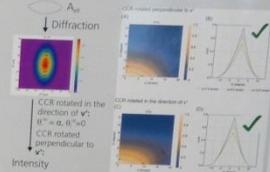


Velocity aberration α is between 0° and 1 arcsec

Design of the recessed cube corner retroreflector (CCR)

SLR Station on Earth

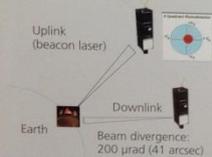
Does the SLR signal peak when the retroreflector points towards the SLR station?



CCR rotated in the direction of \vec{v}_s : $\theta^* = \alpha$, $\theta^* = 0$
CCR rotated perpendicular to \vec{v}_s : $\theta^* = 0$

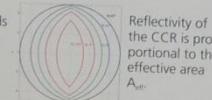
Challenge of accurate pointing

The attitude control system (ACS) needs to be accurate by $\pm 1^\circ$ (remaining pointing accuracy comes from active beam steering)



Uplink (beacon laser)
Downlink
Beam divergence: 200 μ rad (41 arcsec)

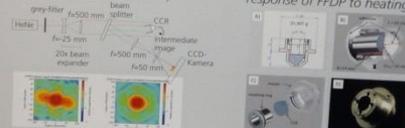
Calculation of the field of view



Reflectivity of the CCR is proportional to the effective area A_{eff}

Manufacturing and testing

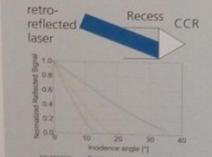
- Measurement of the far-field diffraction pattern (FFDP)
- CAD design, manufacturing, glueing, response of FFDP to heating, vibration



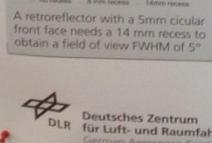
grey-filter, $f=500$ mm, beam splitter, CCR, intermediate stage, CCD-Kamera, $f=25$ mm, 20x beam expander, $f=500$ mm, $f=500$ mm

Attitude verification via SLR

Goal: Independent verification of the functioning of the ACS via SLR to $\pm 1^\circ$



retro-reflecting laser



no recess, 8 mm recess, 14 mm recess

A retroreflector with a 5mm circular front face needs a 14 mm recess to obtain a field of view FWHM of 5°

Future plans:

- Smart retroreflectors + arrays
- SLR of the CubeSat retroreflector



Correlate the SLR signal to the orientation of the rotating satellite

Retardance	Diffraction
CCR1 0°	0
CCR2 45°	0.5
CCRn	

Retroreflectors with polarimetric ID (could be passive or active as modulated retroreflector)

Knowledge for Tomorrow
Wissen für Morgen



Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center



Second Place

Total Points: 27

Audience Points: 7

Judge Points: 20

Name: Stefanie Häusler

Title:

An SLR receiver to discriminate Single- from Multiphoton Events

Federal Agency for Cartography and Geodesy

An SLR Receiver to discriminate Single- from Multiphoton Events

Stefanie Häusler (1), Johann Josef Eickl (1), Josef Kölbl (2)
(1) Federal Agency for Cartography and Geodesy
(2) Deggendorf Institute of Technology

Abstract
In Satellite Laser Ranging the distance to satellites is determined by laser pulse time-of-flight measurements. To minimize systematic errors in the measurements usually time-correlated single photon counting is applied. This method provides a high dynamic range as long as the signal is kept at the single photon level. Higher signal levels introduce systematic errors. Assuming a Poisson distributed signal, which is valid for a coherent light source such as a laser, the single photon level can be reached at a detection rate of below 10 percent. In Satellite Laser Ranging, however, laser pulses are sent through the turbulent atmosphere. This leads to speckle formation at the satellite and at the ground side. The resulting scintillation leads to fluctuations in the intensity of the received signal. This may introduce systematic errors in the measurement. To investigate the effects of signal strength fluctuations on the accuracy of SLR measurements, we built a photon number sensitive receiver. The receiver allows to discriminate single- from multi-photon events. We want to give an overview of the technical details of this receiver.

Printed Circuit Board design and schematic
Ultra-high-speed discriminator circuit with lowest temperature dependence to analyze the effect of scintillation on SLR measurements by filtering out multiphoton seeded pulses

Main components:
ADCMP580 as comparators: 2x MAX9600 as a delay line:
• Propagation delay: 180ps • Propagation delay: 500ps
• Random jitter: 200fs • Output jitter: 300ps
• Deterministic jitter: 10ps

Single-photon receiver and its output
• SPAD (Single Photon Avalanche Diode): The quenching circuit of the SPAD permits a peak output voltage depending on the detected photons.
• Photomultiplier: A photomultiplier is a linear detector, which means that the peak output voltage of the detector has a linear dependence on the impinging signal strength.

Measurements
SPAD actual voltage depending on single- or different multiphoton events

Timing diagram

Filter performance
Considering the rate of input pulses to output pulses gives a feedback about the quality of the pulse discrimination. In an ideal case there should be a defined cut of a 100% and a 0% transfer rate. Because of the jitter and bandwidth of the input signal with a standard deviation of about 2ns and 10MHz of input the transition rate should also represent this value in this case.

Case 1 (right hand side)
1) ADCMP1 detects the falling edge of the pulse
2) ADCMP2 detects the pulse under the adjusted trigger level (a feedback loop extends the signal to avoid misalignment)
3) ADCMP3 switches in High level because of ADCMP1
4) Two MAX9600 act as a delaying element for the signal of ADCMP1
5) The MUX inside of ADCMP3 is enabled by the delayed signal of the second MAX
6) The latch of ADCMP4 is enabled by the signal of ADCMP2 right before the signal of the delay element sector switch the output low. According to that ADCMP4 is latched while the signal of the delay line passes the input. The output remains high for case 1.

Case 2 (left hand side)
1) ADCMP1 detects the falling edge of the pulse
2) ADCMP2 detects no pulse and hence ADCMP3 and ADCMP4 remain in compare mode
3) Two MAX9600 act as a delaying element for the signal of ADCMP1
4) ADCMP4 is in compare mode and switches to low level. The output signal is the single-photon seeded pulse, which can be detected by the event counter

Histogram of the input to single-photon seeded output (SPAD)
Standard deviation of the input is $\approx 10.42ns$, standard deviation of the trigger level is 2ns

Standard deviation of the input to single-photon seeded output (SPAD) after discriminating on the trigger level (1)

Filter in the peak output voltage of the Digital Delay Discriminator and Fast Rise Time Width Detection Circuit

Transition rate of the single-photon seeded pulse discrimination continued in time

Jitter in the peak output voltage of the Digital Delay Discriminator and Fast Rise Time Width Detection Circuit

Transition rate of the discriminator board represents the jitter of the generated input signal

Outlook
• Testing the discriminator circuit in real measurement
• Analyze the effect of scintillation on the measurement technique
• Derive methods to achieve sub-nm accuracy and precision in SLR

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Federal Agency for Cartography and Geodesy
Frankfurt am Main, 2013

ERIC-DIT



**Thanks for all the
great posters**